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LEVEL II

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ECONOMIC FEASIBILITY STUDY OF THE GEOTHERMAL PROJECT FOR THE NAVAL STATION ADAK, ALASKA

by

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Tables:

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SUMMARY

The Adak Geothermal Project is concerned with the use of geothermal energy as a possible alternative to the present fossil fuel energy system on Adak. Three different types of geothermal energy systems, each based on an assumed different reservoir temperature range, are considered. These systems, which could supply the facilities on Adak with energy for space heating or complete electrical power including electrical heating, are: (1) space heating using either above-ground insulated fiberglass pipelines or in-ground insulated steel pipelines, (2) direct electrical power generation using geothermal fluids either at a central power plant or via individual wellhead generating units, either system producing 25 MWe gross output, or (3) a binary geothermal electrical power generation facility where the geothermal fluids would heat a secondary (binary) fluid which would operate the electrical generating equipment, producing a 25 MWe gross output.

The cost of each system was analyzed, and cost-effectiveness was determined by comparing the investment cost with projected fuel savings. An investment return (payback period) for each system was determined using an 8% annual fuel escalation factor. A comparison was made between the Navy price for JP-5 aviation fuel (main fuel on Adak) and the apparent real cost of this type fuel to other remote regions in Alaska. This gave comparative payback costs of this type of energy system if developed by private industry.

Of all the alternate geothermal systems analyzed, the most attractive is the wellhead generating units; such units would develop a combined 25 MWe gross output utilizing the direct geothermal flow from the well. Wellhead units have been tested to temperature ranges as low as 320°F. An overall low investment ($52.80 million) is required with this system because much of the equipment can be fabricated in the lower 48 states, thus eliminating much of the costs of installation and construction at Adak. A wellhead unit system has the best investment return time (payback period) of all the systems and could be operational within 5 years from the date the reservoir is defined.

The primary question remaining is, what system can the geothermal resource on Adak support? This question can only be answered by drilling the initial production size wells to test the reservoir(s) characteristics (temperature, mass flow, and total dissolved solids). Once these characteristics have been determined, then a compatible geothermal system can be developed.

INTRODUCTION

The Adak Naval Station is located among the Andreonof Island Group in the Aleutian Island Chain (Figure 1). Adak Island is located approximately midway between mainland Alaska and Siberia and serves as the major U.S. military facility in the region. The island itself is about 30 miles long by 20 miles wide, and the military facilities are located on the northern third of the island (Figure 2). The remainder of the island is part of the Aleutian Islands National Wildlife Refuge managed by the U.S. Fish and Wildlife. There are approximately 4500 residents on the Naval Station. At the present time, all electrical power and steam used for space heating is produced by boilers and generators using imported JP-5 aviation fuel. The Naval Station Adak annually requires 4.6 million and 4.3 million gallons of JP-5 for space heating and electrical power generation, respectively.[1]

There is therefore, an urgent need for an alternate energy source to relieve Adak of its dependence on fossil fuels. Geothermal reconnaissance began in 1974 with field work by G.V. Keller and L.T. Grose supported by the Office of Naval Research. Efforts continued in 1976 with geological reconnaissance and geophysical work accomplished by both the United States Geological Survey (USGS) and personnel of the NWC Geothermal Utilization Division.

Geothermal reconnaissance work was centered around the northern portion of the island, approximately 7 miles from the main facility. This area showed the best potential and youngest geologic formations of volcanic origin and the site of two of the known hot springs within the Navy facility.

During the summer of 1977, two heat flow holes, 1058 and 2047 feet, were drilled in this region near Mt. Adagdak to test the geothermal gradient of the area. Data showed a geothermal gradient of 45°F/1000 feet, indicating a lower temperature range and deeper thermal anomaly (300°F at 6000 feet) than predicted by the USGS from their geophysical work (350°F at 4000 to 6000 feet). Because the material encountered in these holes

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[1]Naval Weapons Center. *Trip Report to Naval Station, Adak, Alaska* by Robert F. Barling. China Lake, CA, NWC, 1976. 9 pp. (NWC Department Memorandum.)

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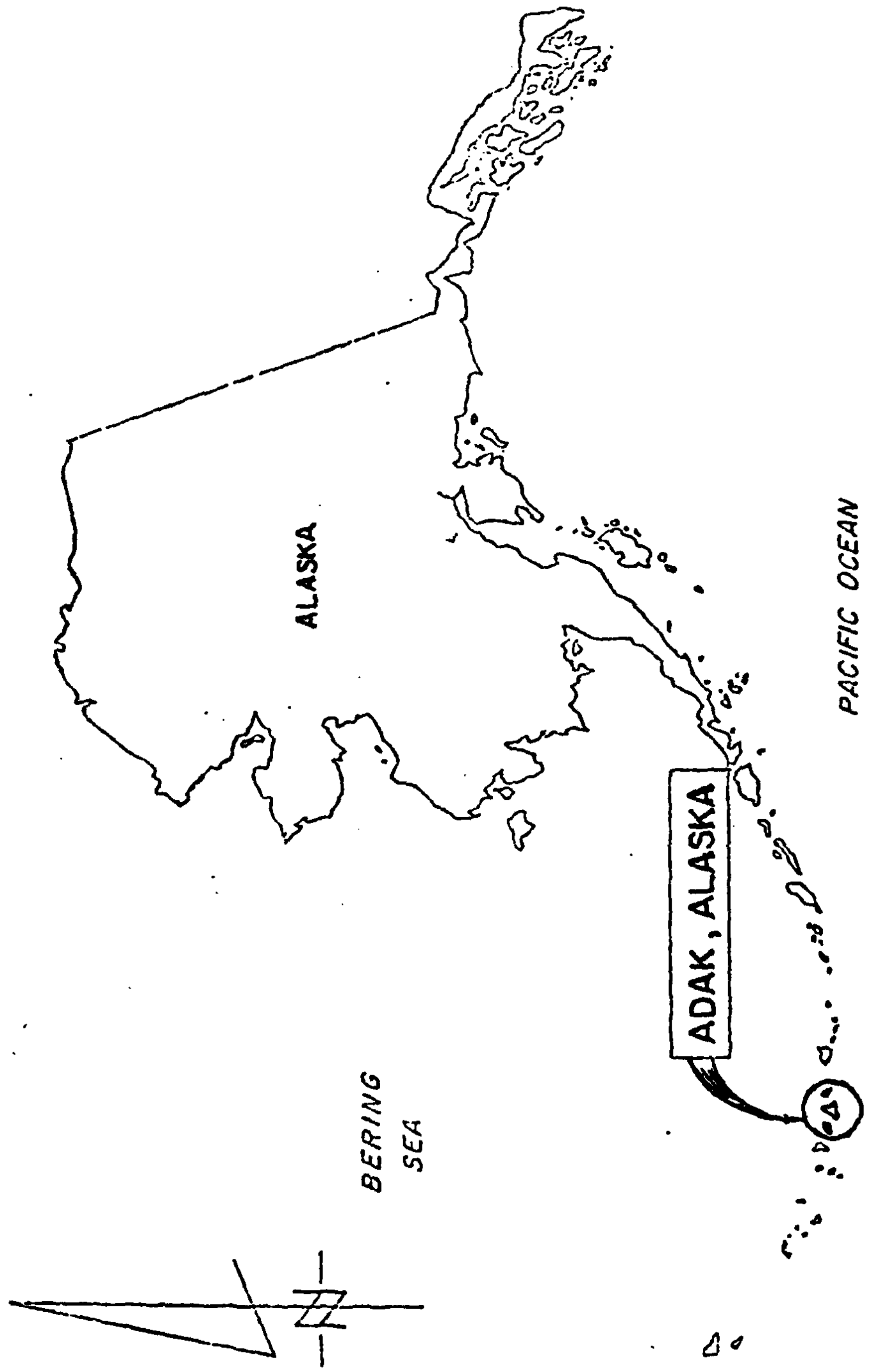

FIGURE 1. Regional Map (Not to Scale).

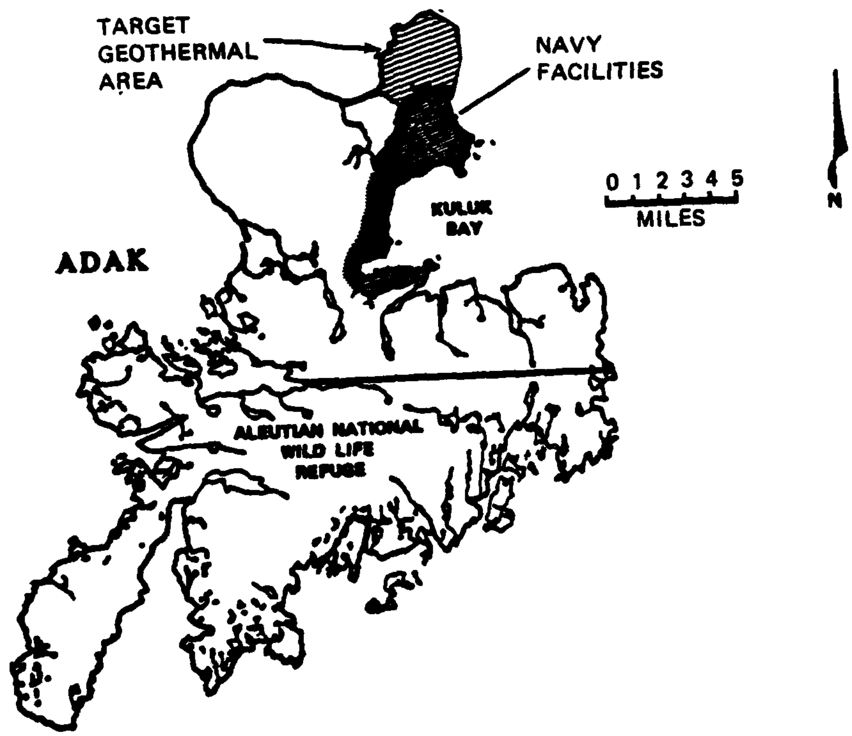

FIGURE 2. Adak Island.

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was largely unconsolidated clay, it may act as an insulating medium, thus not producing a correct thermal gradient. The data collected indicated that at depths of 4000 to 6000 feet, there are probable temperatures adequate to support at least limited and possibly full scale geothermal development. There are no deep tests of the Adak geologic setting to date. However, deep drilling to comparable depths elsewhere in the Aleutian chain and similar geologic areas developed temperatures in excess of 400°F. This proprietary data lends credence to the predicted subsurface condition anticipated in the geothermal reservoir at Adak.

To further evaluate the geothermal potential, wells will have to be drilled to the assumed resource depths, 4000 to 6000 feet. A small number of holes will be sufficient to determine the potential of the resource and what type of energy systems the resource can support.

This report discusses the cost of completing the Adak Geothermal Project by drilling deep wells on Adak and then developing the geothermal resource to its full potential as an energy source for the facilities on Adak. Three different energy systems will be discussed, space heating with geothermal fluids, direct geothermal power generation for all the facility's needs including heating, and binary geothermal power generation for all the facility needs including heating. The type of system eventually developed will depend on the characteristics of the resource (i.e., temperature, volume, and flow capabilities).

GEOTHERMAL ALTERNATIVES

The Adak Geothermal Project is aimed at reducing the fossil fuel requirements on Adak by supplementing or replacing the present fossil fuel system with a cost effective geothermal energy system. With the world's present oil problems and the escalating costs of fossil fuels, a limited-use alternate energy system becomes more reasonable. At the present time, the Navy charges itself $0.456/gal for JP-5 as set by the defense fuel supply costs (DFSC). This is not a true fuel cost in the remote regions of Alaska. Therefore, $1.00/gal for JP-5 will be the assumed real cost because this is comparable to the true costs ($1.00 to $1.50 per gal) for #2 diesel and fuel oil in remote regions in Alaska. Based on both Navy cost and assumed real cost figures, the annual heating and electrical power generation costs are as follows:

JP-5	8,923 million gallons annually
@ $0.456	$4.068 million annually
@ $1.00	$8.923 million annually

Current plans require the drilling of production size wells to a depth of approximately 6000 feet, and analyzing the resource potential with the first few wells (three to four). A total of six wells are planned; standard industrial practice calls for six wells to prove and develop a geothermal field. However, the actual number of wells will depend on the characteristics of the reservoir.

Energy needs at the Naval Station Adak would require the equivalent of a 25-MWe power facility for total electrical use, and a 10-MW thermal power system for space heating only. A combination electrical generation and waste geothermal fluid space heating system is not considered economical; the cost of electrical transmission lines and electrical heaters is less than the geothermal pipelines and space heaters.

The reservoir characteristics (mass flow, temperature, and total dissolved solids (TDS)) will determine the optimum use of the geothermal fluids. The reservoir characteristics will be defined through flow testing of each well as soon as it is completed. Well test results will indicate the number of wells required to meet the 10-MW thermal space heating requirements or the 25-MW electrical system requirements.

A problem encountered in most geothermal fluid reservoirs is the composition of the geothermal fluids themselves. Geothermal fluids are usually classed as brines due to their high TDS values. These dissolved solids can cause either corrosion or scaling in the equipment, thereby creating additional maintenance problems. Thus, materials with a higher resistance to corrosion or scaling must be used and this adds additional cost to the system. Actual fluid composition cannot be determined until the reservoir is tested; however, assumptions can be made based on the projected reservoir temperatures and the projected water source. In Adak the geothermal system water source would probably be a combination of fresh water and sea water.

The current geothermal wellfield design is for six wells in the area between Mt. Adagdak, Andrew Bay, and Clam Lagoon (see Figure 2). The actual well sites have not been determined, but the wells are planned to be of production size to a depth of 6000 feet. The cost of drilling is discussed in Appendix A. Total cost is projected to be $35.0 million including mobilization and demobilization of the drilling equipment, well testing, drilling costs, and wellfield development costs. Additional wells may be required depending on the resource characteristics. Environmental considerations will require a minimum of one well as a reinjection hole for disposal of the waste geothermal fluids and replenishment of the reservoir fluids. Additional uses may be found for the geothermal waste fluids. The waste fluid section of this report discusses alternate uses of these fluids.

ALTERNATE SYSTEMS

Three possible geothermal system alternatives are discussed based on a given resource temperature range. These are:

1. Space Heating - using the geothermal fluids as the heat source or the heating medium. Temperature range: 175°F+.

2. Direct Geothermal Power Generation - using the geothermal fluids to operate the turbines which will produce 25 MWe (gross) for complete electrical conversion of the facilities. Temperature range: 350°F+.

3. Binary Geothermal Power Generation - using a secondary fluid heated by the geothermal fluids to operate the turbines which will produce the 25 MW of power. Temperature range: 250°F+.

Each system can either reduce or eliminate the present fossil fuel dependent energy system on Adak and includes reserving present systems only as a backup. Each alternate system will be discussed noting its positive and negative aspects in relation to the current system.

Space Heating

A space heating system for the facilities on Adak was the initial plan for the development of the geothermal resource. Subsequent analysis of other systems, however, indicate a reasonable economic feasibility if the resource is adequate to support them.

The space heating system using geothermal fluids as the heat source is quite similar to the present fossil fuel system using steam heat, but with a few additions and major modifications (Figure 3). The primary addition to the system, besides the wellfield, is the main feeder and return lines from the wellfield to the Navy facility. The heat carrying medium will depend on the composition of the geothermal fluids. If the composition is such that the fluids can be used directly, the costs of the main line heat exchangers can be eliminated. If the composition is such that there could be excessive corrosion or scaling, then the thermal energy would be transferred to another fluid (probably potable water) via heat exchangers. The warmed potable water would then become the heating medium used in the facilities.

From the main feeder lines, another series of other pipelines will distribute the warm fluids to the individual facilities and individual heaters. Much of the present distribution system can be considered compatible with the geothermal system, but some localized modifications will have to be made. Once the fluids have been used and lost their thermal content, they will be returned to the wellfield for reinjection via a series of return pipelines.

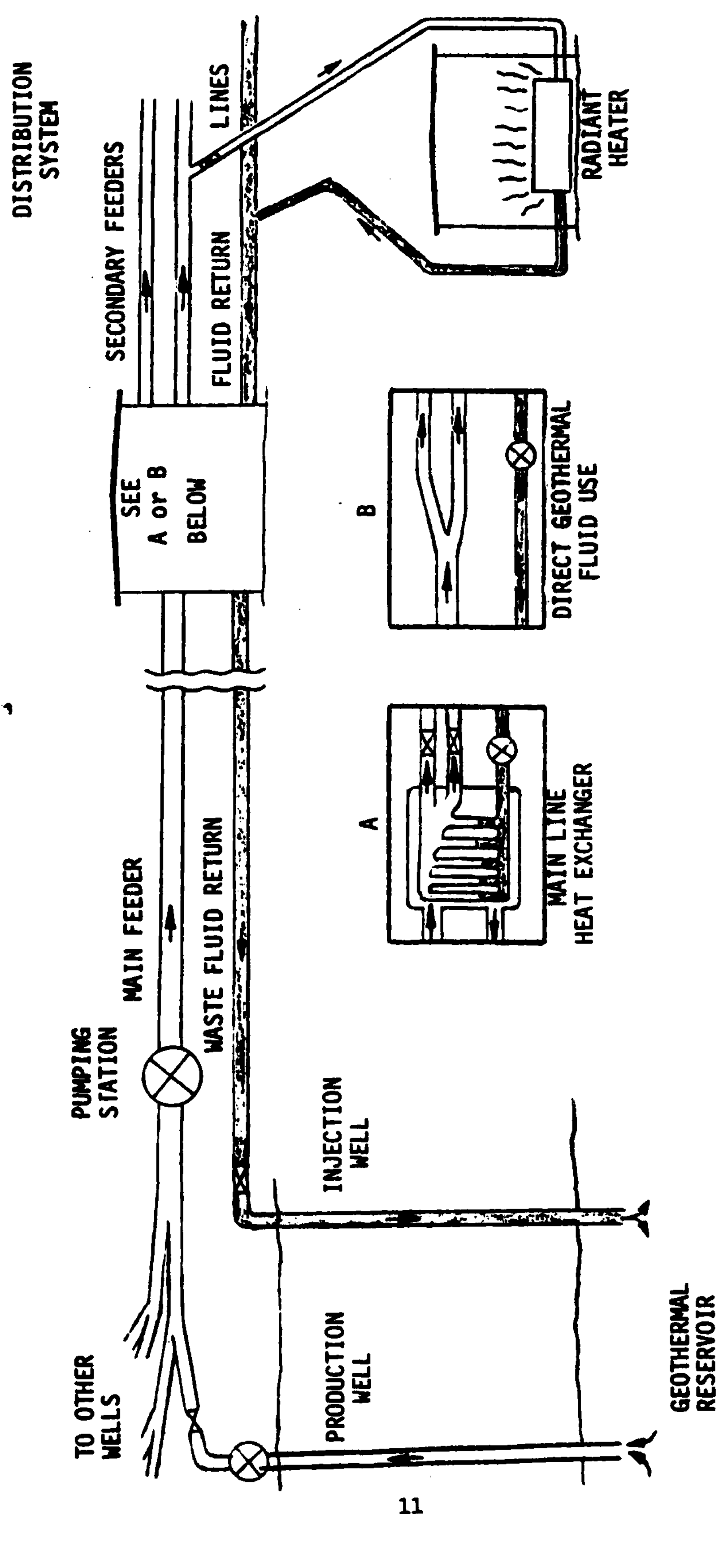

FIGURE 3. Geothermal Fluids Space Heating Schematic.

The efficiency of the system is assumed to be approximately 60%. This energy loss is caused by friction during fluid movement and the lowering of the temperature due to heat transfer through the pipes themselves.

Two types of pipelines have been considered, both are insulated to prevent unnecessary heat loss. The first type is a series of above-ground fiberglass pipelines (Option I-A); the second is a buried dual steel pipeline (Option I-B). Due to the cost of excavation and installation, Option I-B has a higher initial cost, but it also has a greater thermal efficiency. The actual pipeline diameters will be determined during well testing, but are assumed to be approximately 12 inches.

The projected costs for Option I-A are from studies by the Mechanical Engineering Department at Brigham Young University under a series of Navy contracts. Option I-B was developed with the assistance of Energy Systems, Inc., of Anchorage, Alaska, who have developed geothermal pipeline proposals in the past. Table 1 indicates the estimated costs for the space heating systems; the actual cost breakdown is given in Appendix B.

TABLE 1. Geothermal Space Heating Systems ($\$ \times 10^6$).

Option	Costs w/o wellfield	Cost w/wellfield
I-A	6.90	41.90
I-B	13.70	48.70

Direct Geothermal Power Generation

If the resource can support direct power generation using the geothermal fluids, this may be the most cost-effective system. This would release the facilities on Adak from any dependence on fossil fuel for energy generation except for limited emergency backup. With unpredictable escalating fuel costs and the problem of protecting the fuel transports during a national emergency, this type of system can be considered attractive even with its higher initial investment. The payback period for dollars saved in fuel costs is similar to the space heating system and adds to the attractiveness of the system. The key question with direct geothermal power is, will the reservoir have high enough temperatures and mass flow to support the system?

Two options were analyzed for utilizing direct geothermal power production based on a 25-MWe (gross) power output. This output would be sufficient to carry the load required for the total electrical service including heating. The wellfield would be the same as in the other systems with a different wellfield pipeline system.

The first alternative (Option II-A) is a standard geothermal power plant (Figure 4) located within or next to the wellfield. A standard geothermal power plant requires steam to operate the turbines or other prime movers. In a normal fluid-dominated geothermal reservoir, the fluids must be flashed to steam. The Adak geothermal reservoir is assumed to be of this type. A central geothermal power plant is considered to cost approximately $1,080/kW in the lower 48 states. With a cost factor of 3, this would equate to a cost of $3,240/kW for Adak. An additional $3.0 million has been added for transmission lines and electrical heaters.

The second alternative (Option II-B) incorporates a wellhead device called the helical screw expander (Figure 5). This approach appears the most attractive for the Adak Geothermal Project as it has the best economics and feasibility of any of the nonspace heating systems. Also this option is considered better in some respects than the space heating systems. This system utilizes individual wellhead screw-expander driven generators. The helical screw expander is designed to operate on a full flow principle using both steam and the geothermal fluids. They can be installed adjacent to the wellhead, thus eliminating the construction costs of the central-type geothermal power plants (Option II-A). Production models of the helical screw expander are currently being tested and appear to be very efficient. A 1-MW unit was tested at Roosevelt Hot Springs in Utah and operated at about 40% efficiency (Figure 6). The efficiency of the units is thought to increase with time as a helical screw develops a self-lapping layer of scale. These units appear very promising and could be used where a relatively small electrical output is needed, such as Adak's approximate load of 25 MWe.

These units cost approximately $500/kW and could be prefabricated as skid-mounted units in the lower 48 states to eliminate much of the installation costs for Adak. The only costs incurred on Adak would be on-site installation, shipping, and the $3.0 million for transmission lines and electrical heaters.

Power generated by the geothermal plant would be transmitted over the existing electrical distribution system. Thus the present fossil fuel plant can be used as a backup power source when the geothermal plant is down or overloaded.

Table 2 shows the total capital investment for the direct use of geothermal fluids for generating 25 MWe (gross) power output. The wellhead units are only slightly more costly but provide for much more energy usage than the space heating systems (Options I-A and I-B).

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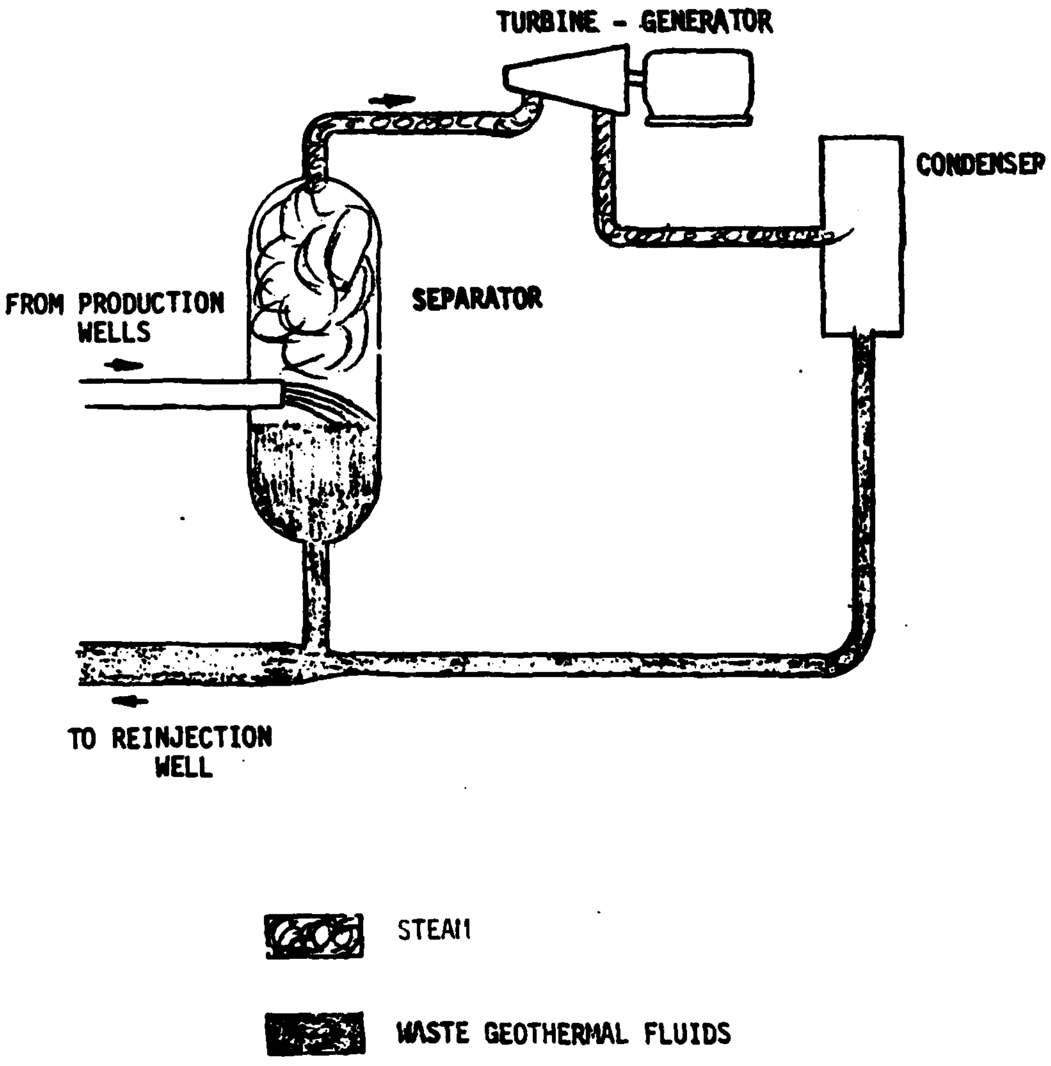

FIGURE 4. Single Flash Geothermal Power Generating Schematic.

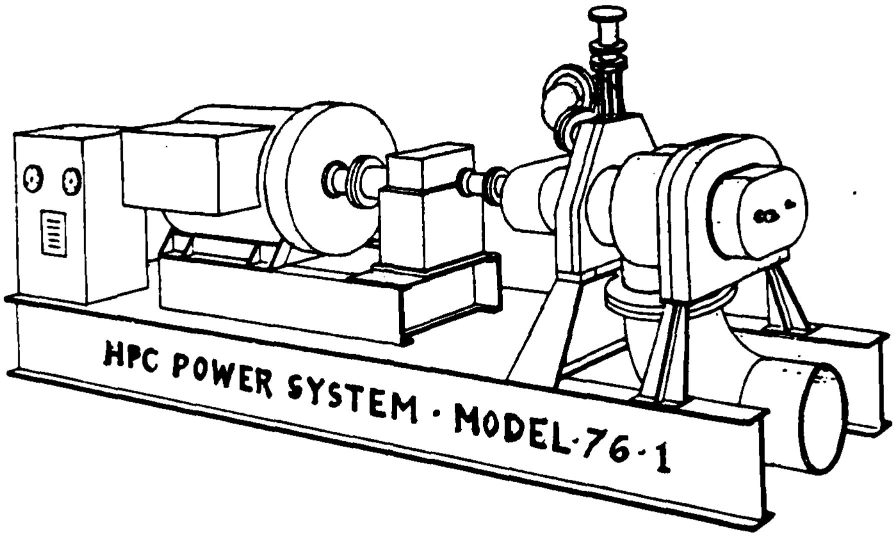

FIGURE 5. Helical Screw Expander (1250 kVA Unit for Geothermal Wellhead Power).

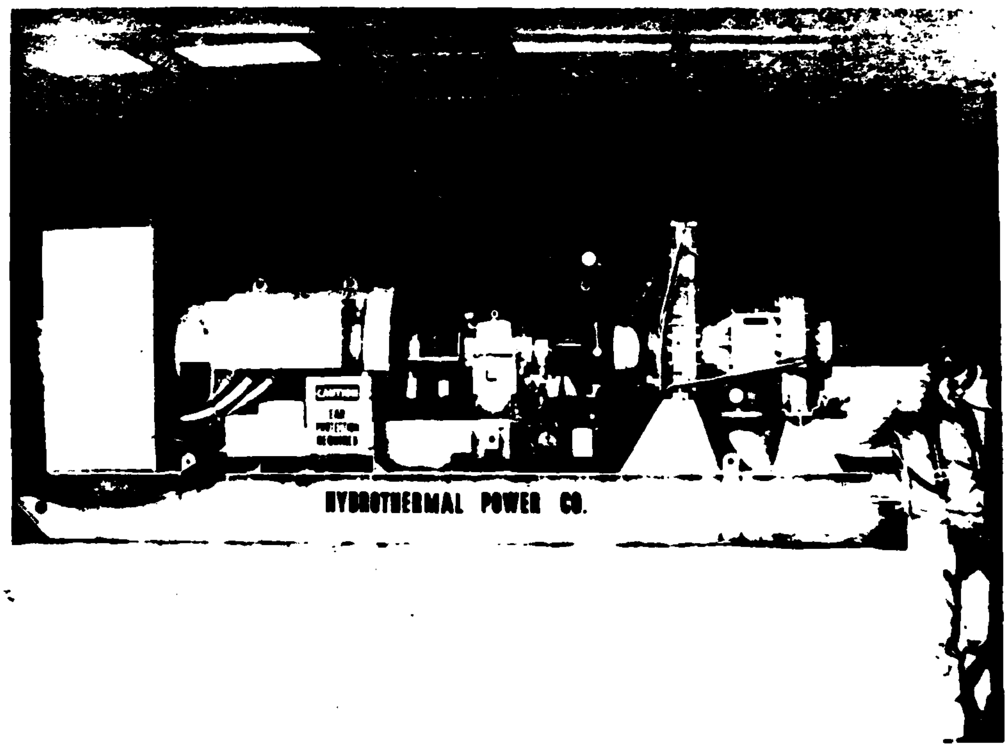

FIGURE 6. 1-MW Unit Undergoing Tests at Roosevelt Hot Springs, Utah.

TABLE 2. 25 MWe Geothermal Power Plant.

Option	$/kW-Adak	Transmission/heaters	Total w/wellfield costs
II-A	$3,240	$3.0 x 10^6	$119.0 x 10^6
II-B	$ 500	$3.0 x 10^6	$52.8 x 10^6

Binary Geothermal Power Generation

The binary geothermal power facility (Figure 7) is very similar to Option II-A, except a secondary fluid is heated by the geothermal fluids and then used to operate the turbines. This system is designed for geothermal reservoirs which do not produce enough steam to efficiently operate the turbine generators. The secondary fluid has a lower boiling point than water or brines; thus it can be changed from the liquid to the gaseous state at lower temperatures. The two fluids are recirculated through a heat exchanger and condenser to change from liquid to gas and then back to liquid. The geothermal fluids are used to convert the secondary fluid to a gas.

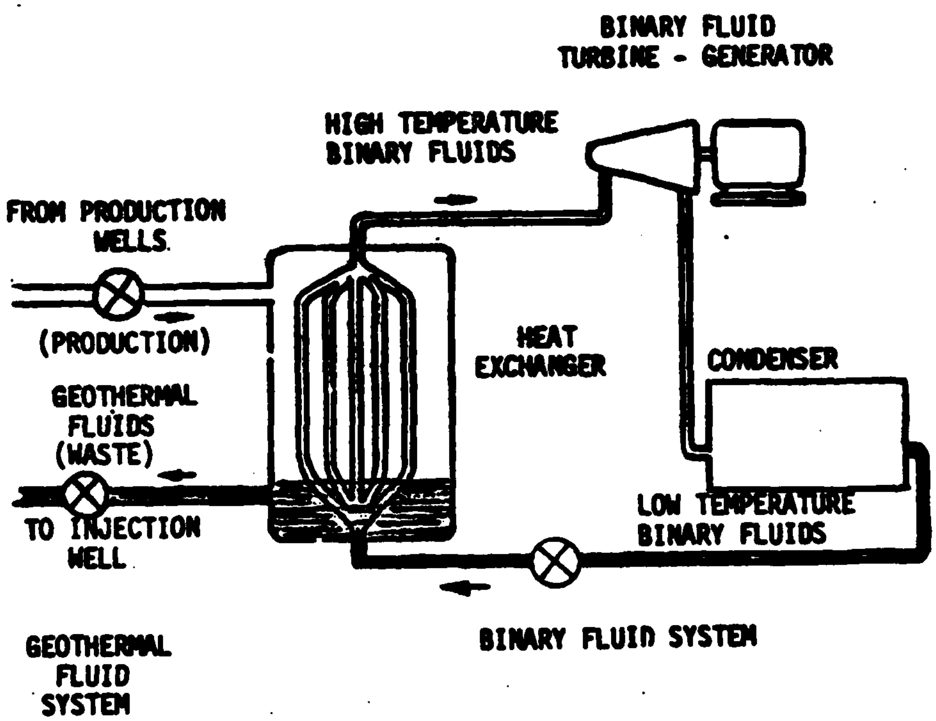

FIGURE 7. Binary Fluid Geothermal Power Generating Schematic.

There are no operating facilities of this type in the country; however, there are a few on-site test units. A 2.3-MW on-site test-production unit is being constructed in the East Mesa known geological resource area (KGRA) in California. Additionally, with this type of system, many of the secondary fluids are excellent fuel-air explosives. The housing for binary systems must be designed as a positive pressure facility to prevent any problems resulting from leaks in the system.

The additional equipment needed and the potential problems of this type of system results in increased cost. A binary facility in the lower 48 states would cost approximately $1,620/kW. In Adak the cost would be $4,860/kW. This system would also require the $3.0 million for transmission lines and heaters. The costs listed in Table 3 are for a 25-MWe facility on Adak.

TABLE 3. 25 MWe Binary Geothermal Power Plant.

$/kW-Adak	Transmission/ heaters	Total w/wellfield costs
Similar to $4,680 Option II-A	$\$3.0 \times 10^6$	$\$159.5 \times 10^6$

WASTE FLUID DISPOSAL

The disposal of waste geothermal fluids is an environmentally sensitive problem created by the composition and temperature of the geothermal fluids. The planned disposal method for the Adak Geothermal Project is reinjection of the fluids into the reservoir. This will require one or more wells in addition to the production wells. One of the six wells presently planned would be used as an injection well.

If the composition of the waste fluids is similar to the surrounding sea waters, the fluids could be discharged into the ocean. This would contribute to an increase in the fish and shellfish population around the discharge area due to the increased water temperature near the discharge point. This would increase the local fisheries and could possibly supply the facilities with seafood under a local contract or co-op of base residents.

Prior to fluids disposal by reinjection or piping to the sea, the remaining thermal energy of the fluids could be further utilized. Heat could be used for a community recreation facility, such as a swimming pool, or greenhouses for growing fresh produce for the island residents as is done extensively in Iceland, Eastern Europe and in Siberia. This would reduce the need for weekly airlifts to supply fresh produce to Adak, and result in a significant cost reduction in the support of the Adak community.

ECONOMIC ANALYSIS

This economic analysis was developed by studying the capital investment requirements of the various systems and relating these to the projected fuel cost savings. The economic feasibility of each system can be rated on its cost effectiveness over a 30-year project life. The principle parameters not yet determined are the reservoir characteristics (temperature, mass flow, and TDS). The system eventually developed will be determined by these reservoir characteristics. The data collected to date appear very favorable, but the actual characteristics can only be known by testing wells drilled to the projected reservoir depth (4000 to 6000 feet). Thus, the largest risk of the project, as in any drilling project, is in proving the reservoir and its actual characteristics.

Fuel costs were calculated (Tables 4 and 5) based on total power and space heating, and space heating only requirements. An annual inflation rate of 8% was used for both the DFSC-set Navy price ($0.456/gal) and the apparent real cost ($1.00/gal). Two separate investment-payback relationships were thus developed (Table 6). Investment returns were indicated for both the artificial cost and the assumed real cost. Maximum fuel conservation and economic feasibility dictates a total electrical system. However, if the resource cannot support this type of system, the utilization of the reservoir for space heating purposes will still be feasible and economical.

Adak costs are computed by the following formula for most capital expenditures. Material costs and labor costs entered into the formula average West Coast costs for a similar job with the escalation to Adak costs as follows:

(Material Cost) (.15*) = MC

[(MC)+(Labor Cost)] (3) = Adak Area Cost

*Shipping costs figured at 15%.

This formula was developed by the Navy as a cost guideline for remote sites such as Adak. All of the civilian contract labor help are brought from the Anchorage and Seattle areas.

CAPITAL INVESTMENTS

The capital investments for the project (Table 7) include wellfield and system expenditures. The wellfield costs include wells, well pumps, and collector and return line; the system costs include the capital equipment for that system, design costs, and installation costs. Once the reservoir has been proven, the actual number of wells to support the

TABLE 4. FUEL COSTS FOR TOTAL
ADAK POWER GENERATION AND SPACE HEATING
WITH AN 8% ANNUAL INFLATION RATE
(FY78 $ X 10^6)

YEAR	10% DISCOUNT FACTOR (DF)	$0.456/GAL[a]	X (DF)	$1.00/GAL	X (DF)
1	.9538	4.231	4.035	9.280	8.851
2	.8671	4.57	3.963	10.022	8.690
3	.7883	4.936	3.891	10.824	8.532
4	.7166	5.33	3.819	11.690	8.377
5	.6515	5.758	3.751	12.625	8.225
6	.5922	6.218	3.682	13.635	8.075
7	.5384	6.715	3.615	14.726	7.928
8	.4895	7.252	3.550	15.904	7.785
9	.4450	7.833	3.486	17.177	7.644
10	.4045	8.460	3.442	18.551	7.504
11	.3677	9.136	3.359	20.035	7.367
12	.3343	9.867	3.299	21.638	7.234
13	.3039	10.657	3.239	23.369	7.102
14	.2763	11.509	3.180	25.238	6.973
15	.2512	12.430	3.122	27.257	6.847
16	.2283	13.424	3.065	29.438	6.721
17	.2076	14.498	3.010	31.793	6.600
18	.1887	15.658	2.955	34.336	6.479
19	.1716	16.911	2.902	37.083	6.363
20	.1560	18.263	2.849	40.050	6.248
21	.1418	19.725	2.797	43.254	6.133
22	.1289	21.303	2.746	46.714	6.021
23	.1172	23.007	2.696	50.451	5.913
24	.1065	24.847	2.646	54.487	5.803
25	.0968	26.835	2.598	58.846	5.696
26	.0880	28.982	2.550	63.554	5.593
27	.0800	31.300	2.504	68.638	5.491
28	.0728	33.804	2.461	74.129	5.397
29	.0661	36.509	2.413	80.060	5.292
30	.0601	39.429	2.370	86.464	5.196
TOTAL	9.891		93.85		206.00

W/O Inflation escalator, W/ discount factor	4.068 x 9.891 40.287	8.923 x 9.891 88.257

[a]As stated previously, this is not considered a true value and is not comparable to the cost of fuel elsewhere in the area. This is the DFSC-set price which does not include shipping and handling costs.

TABLE 5. FUEL COSTS FOR SPACE HEATING WITH AN 8% ANNUAL INFLATION RATE (FY78 $ X 10^6)

YEAR	10% DISCOUNT FACTOR (DF)	$0.456/GAL[a]	X (DF)	$1.00/GAL	X (DF)
1	.9538	2.199	2.097	4.821	4.598
2	.8671	2.374	2.058	5.206	4.514
3	.7883	2.564	2.021	5.623	4.433
4	.7166	2.769	1.984	6.072	4.351
5	.6515	2.991	1.949	6.558	4.273
6	.5922	3.230	1.913	7.083	4.195
7	.5384	3.489	1.878	7.650	4.119
8	.4895	3.768	1.844	8.261	4.044
9	.4450	4.069	1.811	8.922	3.970
10	.4045	4.395	1.778	9.636	3.898
11	.3677	4.746	1.745	10.407	3.827
12	.3343	5.126	1.714	11.240	3.758
13	.3039	5.536	1.682	12.139	3.689
14	.2763	5.979	1.652	13.110	3.622
15	.2512	6.457	1.622	14.159	3.557
16	.2283	6.974	1.592	15.291	3.491
17	.2076	7.532	1.564	16.515	3.429
18	.1887	8.134	1.535	17.836	3.366
19	.1716	8.785	1.508	19.263	3.306
20	.1560	9.488	1.480	20.804	3.245
21	.1418	10.247	1.453	22.468	3.186
22	.1289	11.067	1.427	24.266	3.128
23	.1172	11.952	1.401	26.207	3.071
24	.1065	12.908	1.375	28.303	3.014
25	.0968	13.941	1.349	30.568	2.959
26	.0880	15.056	1.325	33.013	2.905
27	.0800	16.261	1.301	35.654	2.852
28	.0728	17.562	1.279	38.506	2.803
29	.0661	18.967	1.254	41.587	2.749
30	.0601	20.484	1.231	44.914	2.699
TOTAL	9.891		48.821		107.00
W/O Inflation escalator, W/ discount factor		2.114 x 9.891 20.910		4.635 x 9.891 45.845	

[a]As stated previously, this is not considered a true value and is not comparable to the cost of fuel elsewhere in the area. This is the DFSC-set price which does not include shipping and handling costs.

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TABLE 6. Investment Return Figures for Three Geothermal Energy Systems for Adak NAVSTA ($ X 10⁶).

ITEM	30 YR FUEL SAVINGS (1)		CAPITAL INVESTMENT (2)	ANNUAL O & M	INVESTMENT RETURN YEAR (3)	
	@$0.456/GAL	@$1.00/GAL			@$0.456/GAL	@$1.00/GAL
I SPACE HEATING	48.82	107.0				
a) Option I-A			41.90	0.70	24	10
b) Option I-B			48.70	1.40	30	13
II. DIRECT GEOTHERMAL POWER GENERATION (25MW)	93.85	206.0				
a) Option II-A			119.00	8.40	28	11
b) Option II-B			52.80	1.50	14	6
III. BINARY GEOTHERMAL POWER GENERATION (25MW) OPTION III	93.85	206.0	159.50	12.50	45	21

(1) Assuming 8% annual fuel escalation rate and 10% discount.

(2) Includes 35.0 million for six wells
- 33.1 Drilling Cost
- 1.9 Well Test & Wellfield development

(3) Year in which project's capital investment is equalled by sum of annual fuel costs.

OPTIONS:
- I-A - Insulated Fiberglass Pipe above ground
- I-B - Insulated Steel Pipe, buried.
- II-A - Central Power Plant
- II-B - Wellhead Power Units
  Assuming 5MW per well w/injection well

system can be determined. At the present time, six wells are assumed to be able to support the system. If additional wells are needed, the additional capital investment shows an economic return of usually less than 1 year.

TABLE 7. Capital Investment.

Wellfield ($ x 10^6)		
Drilling costs per well (see Appendix A)		$5.183
Testing and development costs per well		$0.317
Initial equipment mobilization and demobilization		$2.000
Total capital investment for six wells		$35.000
Space heating* ($ x 10^6)	wo/wellfield costs	w/wellfield costs
Option I-A: Fiberglass pipelines	6.90	41.90
Option I-B: Dual steel pipelines	13.70	48.70
Direct geothermal power (25 MW)		
Option II-A: Central power plant	84.00	119.00
Option II-B: Wellhead units	17.80	52.80
Binary geothermal power (25 MW)		
Option III: Central power plant	124.50	159.50

*See Appendix B for cost breakdowns.

RECURRENT COSTS

For the Adak Geothermal Project, the annual operations and maintenance costs (O&M) are the only recurring costs other than auxiliary fuel supply costs for the backup system. The calculated O&M costs do not include these auxiliary fuel costs nor do they include the O&M costs of the present electrical system if the space heating system is the only one which

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can be developed. O&M costs vary greatly in geothermal systems, but were assumed to be 10% of the capital investments for the system excluding wellfield costs. The annual O&M costs are shown in Table 6 with the capital investment and fuel savings.

CAPITAL INVESTMENT VS. INVESTMENT RETURN

Investment return periods were calculated using both the artificial and real fuel costs on the 8% annual escalation rate and then stated on investment return year (Table 6). The detailed economic calculation sheets required by P-442[2] are given as Appendix C. The investment return year is that year in which the sum of the annual escalated fuel costs equal or surpass the capital investments. In all systems, the annual O&M costs (Table 8) are nearly equal to the escalated fuel costs after a few years, except for the Binary Geothermal Power System which is slightly higher.

For each system, the investment return year is less than the project year (PY) 20 at the artificial fuel cost and less than PY 15 for the apparent real fuel cost. Thus, each system can be considered to be cost effective for the project's 30-year life span. The present worth or present value costs for the 30-year projects are listed in Table 9 with the actual 30-year costs for each system.

CONCLUSIONS AND RECOMMENDATIONS

The data collected to date on the Adak Geothermal Project clearly indicates the feasibility of developing an economical geothermal energy system to replace or support the present fossil fuel energy system. The resource has only to be proven capable of supporting one of the energy systems in order for the Adak Geothermal Project to be considered economical.

Of the systems which can be utilized by the Navy to support its facilities on Adak, the wellhead power plant system is especially attractive. This particular system has the best overall economics and is the most practical for a remote island operation. Being small and skid-mounted, a problem in one unit would not hamper operation of the remaining units, and the malfunctioning unit can be rapidly replaced.

[2]Naval Facilities Dngineering Command. *Economic Analysis Handbook*. Alexandria, Virginia, NAVFAC, June 1975. (NAVFAC P-442, publication UNCLASSIFIED.)

TABLE 8. Adak Geothermal Project Time Line and Estimated Annual Investments ($ X 10^6).

PROJECT YEAR	1	2	3	4	5	6	7	Annual O&M
Exploration & Production Wells	21.73	11.37						
Wellfield Testing & Development	0.93	0.95	0.02					
Space Heating Option I-A	0.50	3.30	2.00	1.20	0.33			0.7
Space Heating Option I-B	0.50	4.25	4.25	3.45	0.95			1.4
Direct Geothermal Power Option II-A	1.00	10.50	15.50	16.00	16.00	15.00	10.00	8.4
Direct Geothermal Power Option II-B	1.00	3.00	5.50	6.00	2.30			1.5
Binary Geothermal Power Option III	10.00	20.50	22.00	21.00	21.00	20.00	10.00	12.5

TABLE 9. Project Present Worth Costs.

System	Total 30-year costs (FY78 $ x 10^6)	Total present worth costs (FY78 $ x 10^6)
Space heating		
Option I-A	63.33	45.22
Option I-B	90.40	56.77
Direct Geothermal Power		
Option II-A	379.40	182.66
Option II-B	96.30	66.83
Binary Geothermal Power		
Option III	534.50	247.17

The low cost of the wellhead units and the reliability of the whole system makes the wellhead power system a very attractive alternate energy system for Adak. Even if additional wells are required, the investment payback for the additional wells and wellhead units is very reasonable and still economical.

Thus, it is recommended that the wellhead power units (Direct Geothermal Power, Option II-B) be the primary potential energy system for Adak, and that the wellhead design for the test wells should reflect this system.

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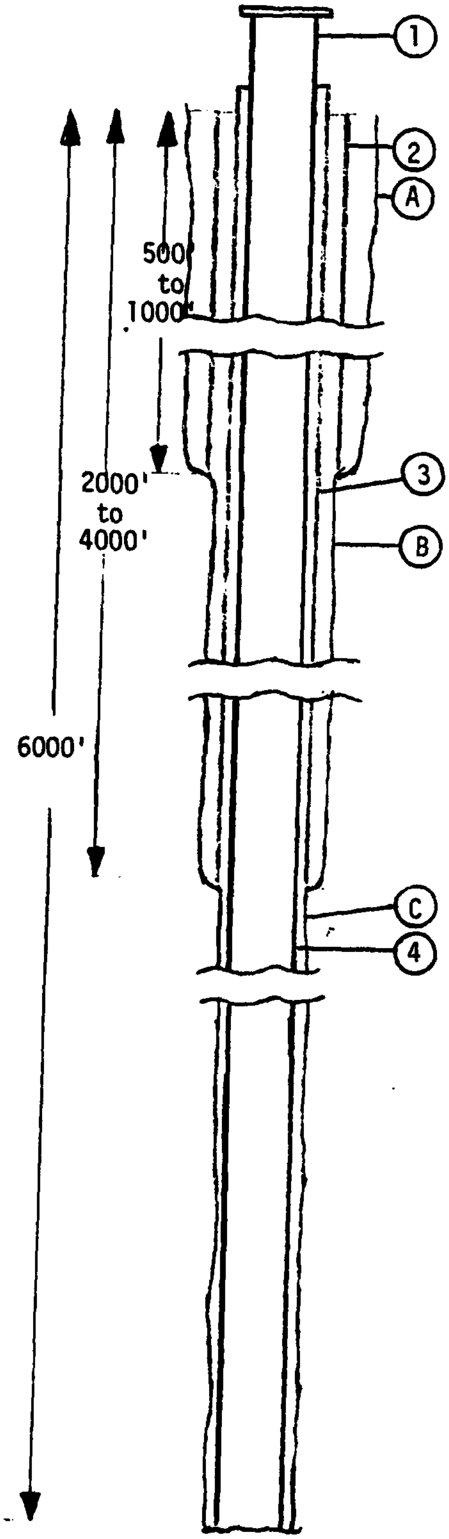
Appendix A

DRILLING COSTS AND WELL SPECIFICATIONS

The drilling costs (Table A-1) and well specifications (Figure A-1) were determined by discussions with personnel in all phases of the geothermal field, both in the industrial and research areas. The figures derived were based on costs in the lower 48 states and then multipled by the Adak conversion equation. The final figures were then discussed with knowledgeable personnel to check on their validity. The results were all favorable and considered reasonable.

TABLE A-1. Approximate Cost Estimate of Drilling the First Adak Deep Geothermal Well to 6000 Feet.

ITEM		($ X 10^6)
1.	Initial mobilization/final demobilization	2.000
2.	Rig Costs-Daily [90 day operation period] Operating $0.012-0.018 per day) Standby 0.010-0.015 per day)+ fuel cost	1.800
3.	Air Compressors Rental 0.0075 per day + fuel	0.300
4.	Casing, Well Head, Valves, Etc.	0.150
5.	Cementing Services and Materials (no transportation)	0.140
6.	Coring	0.075
7.	Bits and Rental Equipment	0.250
8.	Mud, and Air Drilling Chemicals	0.100
9.	H_2S and Safety Alarms	0.008
10.	Well Logging Services (no transportation)	0.150
11.	Consulting Services	0.025
12.	Transportation Costs and Misc.	0.220
13.	Contingency and Downtime	0.165
14.	NWC Support (on & off site)	0.300
15.	Adak NAVSTA Support)	0.500
16.	Adak island contractor support)	
17.	Air transportation for contract services	1.000
	Total Drilling Cost	7.183
	Approximate Cost For Each Additional Well	5.183



A 17¼" Hole
Reamed from 12½"
B 12¼" Hole
C 8¼" Hole

1 7¼" Production Casing
2 9 3/8" Surface Casing
3 13 3/8" Conductor Casing
4 7¼" Slotted Liner or can be left barefoot (no casing in the hole).

FIGURE A-1. Production Well Diagram and Specifications.

Appendix B

SPACE HEATING SYSTEM COSTS

The derivations of the space heating system costs (Table B-1) were all based on the theoretical costs of a system for Adak. Due to the lack of comparable systems in the lower 48 states, no cost comparisons could be made to presently installed systems. As a result, these figures are not as reliable as those in Appendix A, but they are considered reasonable and as accurate as the current data allows.

TABLE B-1. Pipeline and Distribution System Costs for Conversion to Geothermal Use ($\$ \times 10^6$).

	OPTION I-A	OPTION I-B
Well Pump Costs	0.20	.20
Well Field Feeder and Main Line to Facilities	1.8	3.7
Waste Fluid Return Line For Injection	1.15	2.5
Main Line Heat Exchangers	0.30	.6
Pumping Stations	0.25	.5
Distribution Systems	1.90	3.6
Interior Piping & Heaters	1.80	2.6
Total Pipeline - Distribution System	6.90	13.7

OPTION I-A - Insulated above ground Fiberglass Lines

OPTION I-B - Insulated buried Dual Steel Line

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Appendix C

DETAILED ECONOMICS ANALYSIS SHEETS

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CASH FLOW DIAGRAM
SPACE HEATING: OPTION I-A
($ X 10^6)

YEAR	DRILLING COSTS	WELLFIELD DEVELOPMENT & TESTING COSTS	MAIN FEEDER & RETURN LINES	DISTRIBUTION SYSTEMS & HEATERS	OPERATION & MAINTENANCE	TOTAL CASH FLOW	10% DISCOUNT FACTOR	PRESENT WORTH (PV)
1	21.732	0.93	0.5	----	0.70	23.86	.9538	22.76
2	11.366	0.95	2.55	0.75	0.70	16.32	.8671	14.15
3		0.02	1.00	1.00	0.70	2.72	.7883	2.14
4			.20	1.00	0.70	1.90	.7166	1.36
5				.33	0.70	1.03	.6515	0.67
6					0.70	.70	.5922	0.41
7							.5384	
8							.4895	
9							.4450	
10							.4045	
11							.3677	
12							.3343	
13							.3039	
14							.2762	
15							.2512	
16					0.70	.70	.2283	3.73
17							.2076	
18							.1887	
19							.1716	
20							.1560	
21							.1418	
22							.1289	
23							.1172	
24							.1065	
25							.0968	
26							.0880	
27							.0800	
28							.0728	
29							.0661	
30					0.70	0.70	.0601	
TOTAL	33.10	1.90	4.25	3.08	21.00	63.33	9.891	45.22

CASH FLOW DIAGRAM
SPACE HEATING: OPTION I-B
($ X 10^6)

YEAR	DRILLING COSTS	WELLFIELD DEVELOPMENT & TESTING COSTS	MAIN FEEDER & RETURN LINES	DISTRIBUTION SYSTEMS	OPERATION & MAINTENANCE	TOTAL CASH FLOW	10% DISCOUNT FACTOR	PRESENT WORTH
1	21.732	0.93	0.50	----	1.4	24.56	.9538	23.43
2	11.366	0.95	2.50	1.75	1.4	17.97	.8671	15.58
3		0.02	2.50	1.75	1.4	5.67	.7883	4.47
4			1.70	1.75	1.4	4.85	.7166	3.48
5				0.95	1.4	2.35	.6515	1.53
6					1.4	1.4	.5922	0.83
7							.5384	
8							.4895	
9							.4450	
10							.4045	
11							.3677	
12							.3343	
13							.3039	
14							.2762	
15					1.4	1.4	.2512	7.45
16							.2283	
17							.2076	
18							.1887	
19							.1716	
20							.1560	
21							.1418	
22							.1289	
23							.1172	
24							.1065	
25							.0968	
26							.0880	
27							.0800	
28							.0728	
29							.0661	
30					1.4	1.4	.0601	
TOTAL	33.10	1.90	7.20	6.20	42.0	90.40	9.891	56.77

CASH FLOW DIAGRAM
DIRECT GEOTHERMAL POWER (25 MW)
CENTRAL POWER PLANT (OPTION II-A)
($ X 10^6)

YEAR	DRILLING COSTS	WELLFIELD DEVELOPMENT & TESTING COSTS	PLANT DESIGN AND CONSTRUCTION COSTS	TRANSMISSION LINES COSTS	OPERATION & MAINTENANCE	TOTAL CASH FLOW	10% DISCOUNT FACTOR	PRESENT WORTH
1	21.732	0.93	1.00	-----	8.40	32.06	.9538	30.58
2	11.366	0.95	10.00	0.5	8.40	31.22	.8671	27.07
3		0.02	15.00	0.5	8.40	23.92	.7883	18.86
4			15.00	1.0	8.40	24.40	.7166	17.49
5			15.00	1.0	8.40	24.40	.6515	15.90
6			15.00	----	8.40	23.40	.5922	13.86
7			10.00	----	8.40	18.40	.5384	9.91
8					8.40	8.40	.4895	8.40
9							.4450	
10							.4045	
11							.3677	
12							.3343	
13							.3039	
14							.2762	
15					8.40	8.40	.2512	40.59
16							.2283	
17							.2076	
18							.1887	
19							.1716	
20							.1560	
21							.1418	
22							.1289	
23							.1172	
24							.1065	
25							.0968	
26							.0880	
27							.0800	
28							.0728	
29							.0661	
30					8.40	8.40	.0601	
TOTAL	33.10	1.90	81.00	3.00	252.00	379.40	9.891	182.66

CASH FLOW DIAGRAM
DIRECT GEOTHERMAL POWER (25 MW)
WELLHEAD UNITS (OPTION II-B)
($ X 10^6)

YEAR	DRILLING COSTS	WELLFIELD DEVELOPMENT & TESTING COSTS	WELLHEAD UNITS INSTALLED COSTS	TRANSMISSION LINES COSTS	OPERATION & MAINTENANCE	TOTAL CASH FLOW	10% DISCOUNT FACTOR	PRESENT WORTH
1	21.732	0.93	1.00	----	1.5	25.16	.9538	24.00
2	11.366	0.95	2.50	0.50	1.5	16.82	.8671	14.58
3		0.02	5.00	0.50	1.5	7.02	.7883	5.53
4			5.00	1.00	1.5	7.50	.7166	5.37
5			1.30	1.00	1.5	3.80	.6515	2.48
6					1.5	1.50	.5922	0.89
7							.5384	
8							.4895	
9							.4450	
10							.4045	
11							.3677	
12							.3343	
13							.3039	
14							.2762	
15							.2512	
16							.2283	7.98
17						1.5	.2076	
18					1.5		.1887	
19							.1716	
20							.1560	
21							.1418	
22							.1289	
23							.1172	
24							.1065	
25							.0968	
26							.0880	
27							.0800	
28							.0728	
29							.0661	
30					1.5	1.5	.0601	
TOTAL	33.10	1.90	14.8	3.00	45.0	96.30	9.891	60.83

CASH FLOW DIAGRAM
BINARY GEOTHERMAL POWER (25 MW)
CENTRAL PLANT (OPTION III)

($ X 10^6)

YEAR	DRILLING COSTS	WELLFIELD DEVELOPMENT & TESTING COSTS	PLANT DESIGN AND CONSTRUCTION COSTS	TRANSMISSION LINES COSTS	OPERATION & MAINTENANCE	TOTAL CASH FLOW	10% DISCOUNT FACTOR	PRESENT WORTH
1	21.732	0.93	10.00	----	12.5	45.16	.9538	43.07
2	11.366	0.95	20.00	0.50	12.5	45.32	.8671	39.29
3		0.02	21.50	0.50	12.5	34.52	.7883	27.21
4			20.00	1.00	12.5	33.50	.7166	24.01
5			20.00	1.00	12.5	33.50	.6515	21.83
6			20.00	----	12.5	32.50	.5922	19.25
7			10.00	----	12.5	22.50	.5384	12.11
8					12.5	12.50	.4895	6.12
9							.4450	
10							.4045	
11							.3677	
12							.3343	
13							.3039	
14							.2762	
15							.2512	54.28
16						12.5	.2283	
17					12.5		.2076	
18							.1887	
19							.1716	
20							.1560	
21							.1418	
22							.1289	
23							.1172	
24							.1065	
25							.0968	
26							.0880	
27							.0800	
28							.0728	
29							.0661	
30					12.5	12.5	.0601	
TOTAL	33.10	1.90	121.5	3.0	375.00	534.5	9.891	247.17

SECONDARY ECONOMIC ANALYSIS
SUMMARY OF COSTS
FORMAT A

1. Submitting Department of the Navy Component: NAVAL WEAPONS CENTER
2. Date of Submission: JANUARY 1979
3. Project Title: ADAK GEOTHERMAL STUDY
4. Description of Project Objective: REDUCE FOSSIL FUEL ENERGY LOAD W/GEOTHERMAL ENERGY
5. Alternative: SPACE HEATING - OPTION I-A Economic Life: 30 Years

8. Program/Project Costs ($ X 10^6)

7. Project Year	a. Non-Recurring		b. Recurring Operations	c. Annual Cost	d. 10% Discount Factor	e. Discounted Annual Cost
	R&D	Investment				
1		23.16	0.70	23.86	.9538	22.76
2		15.62	0.70	16.32	.8671	14.15
3		2.02	0.70	2.72	.7883	2.14
4		1.20	0.70	1.90	.7166	1.36
5		0.33	0.70	1.03	.6515	0.67
6			0.70	.70	.5922	0.41
7					.5384	
8					.4895	
9					.4450	
10					.4045	
11					.3677	
12					.3343	
13					.3039	
14					.2763	
15			0.70	.70	.2512	3.73
16					.2283	
17					.2076	
18					.1887	
19	COMPLETED				.1716	
20					.1560	
21					.1418	
22					.1289	
23					.1172	
24					.1065	
25					.0968	
26					.0880	
27					.0800	
28					.0728	
29					.0661	
30					.0601	
9. TOTAL		42.33	21.00	63.33	9.891	45.22

SECONDARY ECONOMIC ANALYSIS

SUMMARY OF COSTS

FORMAT A

10a.	Total Project Cost (discounted)	56.77	
10b.	Uniform Annual Cost (without terminal value)		5.74
11.	Less Terminal Value (discounted)	56.77	
12a.	Net Total Project Cost (discounted)		
12b.	Uniform Annual Cost (with terminal value)		5.74

13. Source/Derivation of Cost Estimates: (Use as much space as required)

SEE ACKNOWLEDGEMENTS

a. Non-Recurring Costs: ($\$ \times 10^6$)

1.) Research & Development:

COMPLETED

2.) Investment:

48.40

b. Recurring Cost(s):

1.40

c. Net Terminal Value:

NONE

d. Other Considerations:

Facilities completely operational in 5 years and system reduces fossil fuel requirements for energy generation by 52%.

14. Name & Title of Principal Action Officer		Date
James L. Bruce	Geologist	Dec. 1978

SECONDARY ECONOMIC ANALYSIS
SUMMARY OF COSTS
FORMAT A

1. Submitting Department of the Navy Component: NAVAL WEAPONS CENTER
2. Date of Submission: JANUARY 1979
3. Project Title: ADAK GEOTHERMAL STUDY
4. Description of Project Objective: REDUCE FOSSIL FUEL ENERGY LOAD W/GEOTHERMAL ENERGY
5. Alternative: SPACE HEATING - OPTION I-B Economic Life: 30 Years

8. Program/Project Costs ($ X 10^6)						
7. Project Year	a. Non-Recurring		b. Recurring	c. Annual	d. 10% Discount	e. Discounted
	R&D	Investment	Operations	Cost	Factor	Annual Cost
1		23.16	1.40	24.56	.9538	25.43
2		16.57	1.40	17.97	.8671	15.58
3		4.27	1.40	5.67	.7883	4.47
4		3.45	1.40	4.85	.7166	3.48
5		0.95	1.40	2.35	.6515	1.53
6			1.40	1.40	.5922	0.83
7					.5384	
8					.4895	
9					.4450	
10					.4045	
11					.3677	
12					.3343	
13					.3039	
14					.2763	
15			1.40	1.40	.2512	7.45
16					.2283	
17					.2076	
18					.1887	
19	COMPLETED				.1716	
20					.1560	
21					.1418	
22					.1289	
23					.1172	
24					.1065	
25					.0968	
26					.0880	
27					.0800	
28					.0728	
29					.0661	
30					.0601	
9. TOTAL		48.40	42.0	90.40	9.891	56.77

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SECONDARY ECONOMIC ANALYSIS

SUMMARY OF COSTS

FORMAT A

10a.	Total Project Cost (discounted)	45.22	
10b.	Uniform Annual Cost (without terminal value)		4.57
11.	Less Terminal Value (discounted)	45.22	
12a.	Net Total Project Cost (discounted)		
12b.	Uniform Annual Cost (with terminal value)		4.57

13. Source/Derivation of Cost Estimates: (Use as much space as required)

SEE ACKNOWLEDGEMENTS

a. Non-Recurring Costs: ($\$ \times 10^6$)

1.) Research & Development:

COMPLETED

2.) Investment:

42.33

b. Recurring Cost(s):

0.70/year

c. Net Terminal Value:

NONE

d. Other Considerations:
Facilities completely operational in 5 years and system reduces fossil fuel requirements for energy generation by 52%.

14. Name & Title of Principal Action Officer		Date
James L. Bruce	Geologist	Dec. 1978

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SECONDARY ECONOMIC ANALYSIS
SUMMARY OF COSTS
FORMAT A

1. Submitting Department of the Navy Component: NAVAL WEAPONS CENTER
2. Date of Submission: JANUARY 1979
3. Project Title: ADAK GEOTHERMAL STUDY
4. Description of Project Objective: REDUCE FOSSIL FUEL ENERGY LOAD W/GEOTHERMAL ENERGY
5. Alternative: 25 MW GEOTH.POWER OPTION II-A
6. Economic Life: 30 Years

8. Program/Project Costs ($ X 10^6)

7. Project Year	a. Non-Recurring R&D	a. Non-Recurring Investment	b. Recurring Operations	c. Annual Cost	d. 10% Discount Factor	e. Discounted Annual Cost
1		23.66	8.40	32.06	.9538	30.58
2		22.82	8.40	31.22	.8671	27.07
3		15.52	8.40	23.42	.7883	18.86
4		16.00	8.40	24.40	.7166	17.49
5		16.00	8.40	24.40	.6515	15.90
6		15.00	8.40	23.40	.5922	13.86
7		10.00	8.40	18.40	.5384	9.91
8			8.40	8.40	.4895	8.40
9					.4450	
10					.4045	
11					.3677	
12					.3343	
13					.3039	
14					.2763	
15			8.40	8.40	.2512	40.59
16					.2283	
17					.2076	
18					.1887	
19					.1716	
20					.1560	
21					.1418	
22					.1289	
23	COMPLETED				.1172	
24					.1065	
25					.0968	
26					.0880	
27					.0800	
28					.0728	
29					.0661	
30					.0601	
9. TOTAL		127.4	252.00	379.40	9.891	182.66

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SECONDARY ECONOMIC ANALYSIS

SUMMARY OF COSTS

FORMAT A

10a.	Total Project Cost (discounted)	182.66	
10b.	Uniform Annual Cost (without terminal value)		18.47
11.	Less Terminal Value (discounted)	182.66	
12a.	Net Total Project Cost (discounted)		
12b.	Uniform Annual Cost (with terminal value)		18.47

13. Source/Derivation of Cost Estimates: (Use as much space as required)

SEE ACKNOWLEDGEMENTS

a. Non-Recurring Costs: ($\$ \times 10^6$)

1.) Research & Development:

COMPLETED

2.) Investment:

127.4

b. Recurring Cost(s):

8.40/year

c. Net Terminal Value:

NONE

d. Other Considerations:

Will completely eliminate the fossil fueled energy system except for use as an emergency back-up.

14. Name & Title of Principal Action Officer		Date
James L. Bruce	Geologist	Dec. 1978

SECONDARY ECONOMIC ANALYSIS
SUMMARY OF COSTS
FORMAT A

1. Submitting Department of the Navy Component: NAVAL WEAPONS CENTER
2. Date of Submission: JANUARY 1979
3. Project Title: ADAK GEOTHERMAL STUDY
4. Description of Project Objective: REDUCE FOSSIL FUEL ENERGY LOAD W/GEOTHERMAL ENERGY
5. Alternative: 25 MW GEOTH. POWER OPTION II-B
6. Economic Life: 30 Years

8. Program/Project Costs ($ X 10^6)

7. Project Year	a. Non-Recurring R&D	a. Non-Recurring Investment	b. Recurring Operations	c. Annual Cost	d. 10% Discount Factor	e. Discounted Annual Cost
1		23.66	1.50	25.16	.9538	24.00
2		15.32	1.50	16.82	.8671	14.53
3		5.52	1.50	7.02	.7883	5.53
4		6.00	1.50	7.50	.7166	5.37
5		2.30	1.50	3.80	.6515	2.48
6			1.50	1.50	.5922	0.89
7					.5384	
8					.4895	
9					.4450	
10					.4045	
11					.3677	
12					.3343	
13					.3039	
14					.2763	
15			1.50	1.50	.2512	7.98
16					.2283	
17					.2076	
18					.1887	
19					.1716	
20					.1560	
21					.1418	
22					.1289	
23	COMPLETED				.1172	
24					.1065	
25					.0968	
26					.0880	
27					.0800	
28					.0728	
29					.0661	
30					.0601	
9. TOTAL		51.30	45.0	96.30	9.891	60.83

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SECONDARY ECONOMIC ANALYSIS

SUMMARY OF COSTS

FORMAT A

10a.	Total Project Cost (discounted)	60.83	
10b.	Uniform Annual Cost (without terminal value)		6.15
11.	Less Terminal Value (discounted)	60.83	
12a.	Net Total Project Cost (discounted)		
12b.	Uniform Annual Cost (with terminal value)		6.15

13. Source/Derivation of Cost Estimates: (Use as much space as required)

SEE ACKNOWLEDGEMENTS

a. Non-Recurring Costs: ($\$ \times 10^6$)

1.) Research & Development:

COMPLETED

2.) Investment:

51.30

b. Recurring Cost(s):

1.50 per year

c. Net Terminal Value:

NONE

d. Other Considerations:

Completely eliminates the fossil fueled energy system except for use as an emergency back-up, at the lowest cost.

14. Name & Title of Principal Action Officer		Date
James L. Bruce	Geologist	Dec. 1978

SECONDARY ECONOMIC ANALYSIS
SUMMARY OF COSTS
FORMAT A

1. Submitting Department of the Navy Component: NAVAL WEAPONS CENTER
2. Date of Submission: JANUARY 1979
3. Project Title: ADAK GEOTHERMAL STUDY
4. Description of Project Objective: REDUCE FOSSIL FUEL ENERGY LOAD W/GEOTHERMAL ENERGY
5. Alternative: 25 MW GEOTH.POWER BINARY(Option III)
6. Economic Life: 30 Years

8. Program/Project Costs ($ X 10^6)

7. Project Year	a. Non-Recurring R&D	a. Non-Recurring Investment	b. Recurring Operations	c. Annual Cost	d. 10% Discount Factor	e. Discounted Annual Cost
1		32.66	12.50	45.16	.9538	43.07
2		32.82	12.50	45.32	.8671	39.29
3		22.02	12.50	34.52	.7883	27.21
4		21.00	12.50	33.50	.7166	24.01
5		21.00	12.50	33.50	.6515	21.83
6		20.00	12.50	32.50	.5922	19.25
7		10.00	12.50	22.50	.5384	12.11
8			12.50	12.50	.4895	6.12
9					.4450	
10					.4045	
11					.3677	
12					.3343	
13					.3039	
14					.2763	
15			12.50	12.50	.2512	54.28
16					.2283	
17					.2076	
18					.1887	
19	COMPLETED				.1716	
20					.1560	
21					.1418	
22					.1289	
23					.1172	
24					.1065	
25					.0968	
26					.0880	
27					.0800	
28					.0728	
29					.0661	
30					.0601	
9. TOTAL		159.50	375.00	534.50	9.891	247.17

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SECONDARY ECONOMIC ANALYSIS

SUMMARY OF COSTS

FORMAT A

10a.	Total Project Cost (discounted)	247.17	
10b.	Uniform Annual Cost (without terminal value)		24.99
11.	Less Terminal Value (discounted)	247.17	
12a.	Net Total Project Cost (discounted)		
12b.	Uniform Annual Cost (with terminal value)		24.99

13. Source/Derivation of Cost Estimates: (Use as much space as required)

SEE ACKNOWLEDGEMENTS

a. Non-Recurring Costs: ($\$ \times 10^6$)

1.) Research & Development:

COMPLETED

2.) Investment:

159.50

b. Recurring Cost(s):

12.50 per year

c. Net Terminal Value:

NONE

d. Other Considerations:

Completely eliminates the fossil fueled energy system, except for use as an emergency back-up. Can operate with lower reservoir temperatures.

14. Name & Title of Principal Action Officer		Date
James L. Bruce	Geologist	Dec. 1978